

DISK DRIVE WITH FLEXIBLE, INTEGRATED  
BREATHER/RECIRCULATION FILTER ELEMENTS

CROSS-REFERENCE TO RELATED APPLICATIONS

5 This patent application claims priority under 35 U.S.C. §119(e) to U.S. Patent Application Serial No. 60/432,157, that was filed on December 10, 2002, and that is entitled "FLEXIBLE 4-IN-1 INTEGRATED CHEMICAL FILTER," the entire disclosure of which is hereby incorporated by reference in its entirety herein.

10 FIELD OF THE INVENTION

The present invention generally relates to the field of disk drives and, more particularly, to filtering systems for disk drives.

BACKGROUND OF THE INVENTION

15 Various types of filters are used in disk drives. Breather filters are commonly used to filter an airflow into the disk drive through a breather port that extends through the disk drive housing (e.g., a hole in the cover; a hole in the base plate). Vapors are typically addressed by filters of this type, for instance by the breather filter utilizing an appropriate adsorbent. Oftentimes this airflow is directed through a meandering or tortuous path to provide a diffusion 20 barrier of sorts, and then through the breather filter. These types of filters may also provide a filtering function for fluids within the interior of the disk drive.

Recirculation filters are also commonly included in disk drives. A fluid flow from within the disk drive is commonly directed through the recirculation filter, and then back into the disk drive. That is, recirculation filters are associated with an internal fluid flow within the disk

drive. These types of filters may provide one or more of a chemical and mechanical filtering function.

Efforts continue to be directed to reducing the overall cost of the disk drive. Reducing the total number of parts can of course reduce the cost of the disk drive. Particulate and 5 chemical filtering functions have been integrated into a single filter in the past. Moreover, filter designs exist that combine a breather filter section and a recirculation filter section. However, the need remains for such a multi-functional filter having a design that is adaptable to low cost mass production in an automated process, that has minimal packaging requirements, that may be shipped in a "flat" form and then manipulated into a different shape during installation, that is 10 easy to install in the disk drive, and that may alleviate the need for a complex diffusion path.

#### BRIEF SUMMARY OF THE INVENTION

A first aspect of the present invention is embodied by a data storage device that includes first and second housing sections that are appropriately interconnected (e.g., a base plate and a 15 cover, respectively). A computer-readable storage medium (e.g., one or more disks) is disposed between the interconnected first and second housing sections. Other structure associated with the data storage device (e.g., one or more actuator arms and associated head-gimbal assemblies; a voice coil, etc) may be disposed between the interconnected first and second housing sections as well, although such additional components are not required by the first aspect.

20 The first housing section in the case of the first aspect includes a first recess on an interior surface of the first housing section. A first port (e.g., a breather port) extends from this first recess to an exterior surface of the first housing section. A filter assembly used by the data storage device includes both a breather filter section and a recirculation filter section. The

breather filter section is disposed/extends within the first recess formed in the first housing section.

Various refinements exist of the features noted in relation to the first aspect of the present invention. Further features may also be incorporated in the first aspect of the present invention 5 as well. These refinements and additional features may exist individually or in any combination. The first port may be of any appropriate configuration. In one embodiment, the first port is axially extending, while in another embodiment the first port meanders between the exterior surface of the first housing section and a portion the interior surface of the first housing section within the first recess. The first port may interface with any appropriate portion of the interior 10 surface of the first housing section within the first recess, including in relation to the breather filter section disposed therein. One embodiment has the first port intersecting with a base associated with the first recess, while another embodiment has the first port intersecting with a perimeter-defining side wall associated with the first recess.

The breather filter section and the recirculation filter section of the filter assembly may be 15 disposed in different orientations when installed in the data storage device of the first aspect. In one embodiment, the recirculation filter section is disposed at least generally perpendicular to the breather filter section when the filter assembly is installed in the data storage device. The breather filter section may be oriented so as to be at least generally parallel with the computer-readable storage medium. In one embodiment, the breather filter section is disposed under the 20 computer-readable storage medium in at least somewhat of a horizontal orientation, while the recirculation filter section is disposed beyond the perimeter of the computer-readable storage medium, for instance in at least somewhat of a vertical orientation. Both the breather filter section and the recirculation filter section may be attached or anchored to the data storage device

in any appropriate manner (e.g., via adhesive). It may be beneficial for the breather filter section to be at least generally flush with perimeter portions of the first housing section that are disposed about the first recess in which the breather filter section is positioned, for instance so as to reduce its impact on the fluid flow within the data storage device during operation.

5        The breather filter section and the recirculation filter section may be disposed within a common packaging in the case of the first aspect. This common packaging may include a hinge of any appropriate type between the breather filter section and the recirculation filter section. This would allow the filter assembly to be shipped in a "flat" orientation, but yet still allow the recirculation filter section to be moved relative to the breather filter section (e.g., pivoted at least 10 generally about the breather filter section) when installing the filter assembly on the first housing section. In one embodiment, the filter assembly may be characterized as a laminated structure, formed entirely of multiple layers or sheets of one or more appropriate materials. Another way to characterize this packaging that may be utilized by the filter assembly is that it may be of a flexible or compliant nature. The above-noted hinge could then be in the form of a necked-down 15 region in the packaging, or otherwise formed directly in that portion of the packaging, that interconnects the breather filter section and the recirculation filter section.

Both the breather filter section and the recirculation filter section may be of any appropriate configuration for the filter assembly used by the first aspect. In one embodiment, the breather filter section is at least generally wedge-shaped in plan view. That is, a pair of opposing 20 side edges of the breather filter section taper inwardly progressing from one end of the breather filter section toward the opposite end of the breather filter section. What may then be characterized as the wide end of the breather filter section may be located at an interconnection between the breather filter section and the recirculation filter section. In the case where the

breather filter section is disposed under or beneath the computer-readable storage medium and where this computer-readable storage medium is in the form of a rotatable disk, this could then dispose the narrow end of the breather filter section closer to a rotational of the disk than the wide end of the breather filter section. Preferably, the breather filter section is disposed at or 5 near the outer diameter of this disk in a low pressure region. The wide end of the breather filter section, the narrow end of the breather filter section, or both may have an arcuate contour or shape in plan view. For instance, the wide end of the breather filter section may extend between the opposing side edges of the breather filter section at least generally parallel with a perimeter of the above-noted rotatable disk. The narrow end of the breather filter section may be disposed 10 at least generally parallel with the wide end as well.

The breather filter section of the filter assembly utilized by the first aspect may include any appropriate filtering media. Typically the filtering media for the breather filter section will provide both a chemical filtration and an adsorption function. An absorbent may be used as the filtering media for the breather filter section, for instance to provide both chemical and humidity 15 control. Representative adsorbents that may be used for the filtering media of the breather filter section for the filter assembly include without limitation, activated carbon, carbon tablets, silica gel tablets, carbon held in PTFE, and carbon held on a web. The filtering media for the breather filter section may be in any appropriate form, may utilize any appropriate material(s), may include any appropriate combination of multiple filtering materials, or any combination of the 20 foregoing.

The recirculation filter section of the filter assembly utilized by the first aspect may include any appropriate filtering media, and may provide idle diffusion resistance and recirculation particle filtration functions. Typically the filtering media of the recirculation filter

section will provide a mechanical filtering function, an electrostatic filtering function (e.g., so as to attract charged particles or such that there is an electrical interaction between the filtering media of the recirculation filter section and at least certain particulates that may exist within the data storage device), or both. The recirculation filter section could also use activated carbon or 5 the like, for instance to provide chemical and humidity control. In the preferred embodiment, the filtering media for the recirculation section is in the form of an electrostatic media. The filtering media for the recirculation filter section may be in any appropriate form, may utilize any appropriate material(s), may include any combination of multiple filtering materials, or any combination of the foregoing.

10 Preferably the portion of the breather filter section that faces the first housing section is spaced from the first housing section in the case of the first aspect. This provides an enhanced access to the breather filter section by a flow emanating from outside the data storage device (and that is directed through the first port and into the noted space between the first housing section and the breather filter section within the first recess).

15 The first recess in the first housing section for the data storage device of the first aspect may be defined in any appropriate manner. In one embodiment, the first housing section includes a perimeter-defining side wall and a base that collectively define the first recess in which the breather filter section of the filter assembly is disposed. In one embodiment, the breather filter section is spaced from both the base and the perimeter-defining side wall of the 20 first housing section that define the first recess. Stated another way, the breather filter section may be separated from the base of the first housing section by a first space, and further may be separated from the perimeter-defining side wall of the first housing section by an annular second space.

An appropriate seal may be provided between the first housing section and the filter assembly, particularly in relation to the breather filter section. In one embodiment, an annular seal is provided about the perimeter of the breather filter section. That is, "about" means that no portion of the seal is disposed over the breather filter section in this case. This would then force

5 any flow from outside the data storage device to first pass through the filtering media of the breather filter section before entering the interior of the data storage device. Another benefit of this type of seal is that the seal itself does not reduce the area through which this flow may proceed through any packaging associated with the breather filter section to reach the filtering media of the breather filter section. This seal may be accomplished in any appropriate manner,

10 including an adhesive that is appropriate for use in a data storage device environment. The adhesive may be in the form of a layer formed on packaging that houses the breather filter section and the recirculation filter section. A removable cover or the like may be provided to expose the adhesive before installing the filter assembly on the first housing section.

The filter assembly utilized by the first aspect may include appropriate packaging for the

15 breather filter section and the recirculation filter section. The breather filter section may include an appropriate filtering media, and the packaging associated with the breather filter section may include first and second packaging sections that are disposed on opposite sides of this filtering media in relation to the flow through the filtering media. The filter assembly in this case is installed such that first packaging section associated with the breather filter section is disposed

20 between the first housing section and the filtering media for the breather filter section. The second packaging section would then be disposed between the filtering media and the second housing section.

In one embodiment of the first aspect, the above-noted first and second packaging sections associated with the breather filter section have a different permeability. Stated another way, the first and second packaging sections provide a different resistance to flow therethrough to reach the filtering media of the breather filter section. For instance, the second packaging 5 section may have a larger or higher permeability than the first packaging section. That is, the packaging may be configured such that there is less resistance to a flow from within the data storage device to the filtering media of the breather filter section through the second packaging section, than to a flow to the filtering media of the breather filter section emanating from outside of the data storage device and directed through the first port and then through the first packaging 10 section. The first packaging section does, however, allow for at least some flow through the first packaging section to the filtering media of the breather filter section.

A flow emanating from outside the data storage device of the first aspect may flow through the first port in the first housing section and into a space between the breather filter section and the portion of the first housing section that defines the first recess. This flow may be 15 directed through any portion of the above-noted first packaging section to reach the filtering media associated with the breather filter section. Stated another way, the entire first packaging section that is disposed over the filtering media of the breather filter section may be made available for a flow to the filtering media from outside the data storage device.

The recirculation filter section used by the filter assembly in accordance with the first 20 aspect may include packaging for containing an appropriate filtering media as well. This packaging may be selected for controlling the flow through the recirculation filter section.

In one embodiment, the data storage device of the first aspect is what is commonly referred to in the art as a disk drive. Disk drives of any appropriate configuration may utilize the

filter assembly that is used by the first aspect.

A second aspect of the present invention is embodied by a data storage device that includes first and second housing sections that are appropriately interconnected (e.g., a base plate and a cover, respectively). A first port (e.g., a breather port) extends from an exterior surface of the first housing section to an interior surface of the first housing section to provide a fluid connection between the environment and the interior of the data storage device. A computer-readable storage medium (e.g., one or more disks) is disposed between the interconnected first and second housing sections. Other structure associated with the data storage device (e.g., one or more actuator arms and associated head-gimbal assemblies; a voice coil, etc.) may be disposed between the interconnected first and second housing sections as well, although such additional components are not required by the second aspect.

A filter assembly used by the data storage device of the second aspect includes both a breather filter section, a recirculation filter section, and an appropriate packaging. Generally, the breather filter section is disposed within a fluid path extending between an interior and an exterior of the data storage device, while the recirculation filter section is disposed within a fluid path that is entirely contained within an interior of the data storage device. The permeability of the packaging associated with the breather filter section is different on the opposite sides of a filtering media that is used by the breather filter section.

Various refinements exist of the features noted in relation to the second aspect of the present invention. Further features may also be incorporated in the second aspect of the present invention as well. These refinements and additional features may exist individually or in any combination. The first port may be of any appropriate configuration. In one embodiment, the first port is axially extending, while in another embodiment the first port meanders between an

exterior surface of the first housing section and an interior surface of the first housing section.

The first housing section associated with the second aspect may include a first recess on its interior surface. The first port may extend from an exterior surface of the first housing section to the interior surface of the first housing section at any appropriate location within this first recess. The first port may interface with any appropriate portion of the interior surface of the first housing section within the first recess, including in relation to the breather filter section that is preferably disposed or extends therein. One embodiment has the first port intersecting with a base associated with the first recess, while another embodiment has the first port intersecting with a perimeter-defining side wall associated with the first recess. In one embodiment, this first recess is formed on a base plate of a disk drive.

The above-noted first recess that may be associated with the first housing section in the case of the second aspect may be defined in any appropriate manner. In one embodiment, the first housing section includes a perimeter-defining side wall and a base that collectively define the first recess in which the breather filter section of the filter assembly may be disposed. In one embodiment, the breather filter section is spaced from both the base and the perimeter-defining side wall of the first housing section that define the first recess. Stated another way, the breather filter section may be separated from the base of the first housing section by a first space, and further may be separated from the perimeter-defining side wall of the first housing section by an annular second space.

One benefit of having the breather filter section being disposed in spaced relation to the first housing section is to enhance the access to the filtering media of the breather filter section. A flow emanating from outside the data storage device of the second aspect may flow through the first port in the first housing section and into a space between the breather filter section and

the portion of the first housing section that defines the first recess. This flow may then be directed through any portion of the packaging that is disposed over the filtering media associated with the breather filter section. Stated another way, the entire portion of the packaging that is disposed over the side of the filtering media of the breather filter section that faces the first 5 housing section may be made available for a flow to the filtering media from outside the data storage device.

An appropriate seal may be provided between the first housing section and the filter assembly in the case of the second aspect, particularly in relation to the breather filter section. In one embodiment, an annular seal is provided about the perimeter of the breather filter section. 10 That is, "about" means that no portion of the seal is disposed over the breather filter section in this case. This would then force any flow from outside the data storage device to first pass through the filtering media of the breather filter section before entering the interior of the data storage device. Another benefit of this type of seal is that the seal itself does not reduce the area 15 through which this flow may proceed through the packaging to reach the filtering media of the breather filter section. This seal may be accomplished in any appropriate manner, including an adhesive that is appropriate for use in a data storage device environment. The adhesive may be in the form of a layer formed on the packaging that houses the breather filter section and the recirculation filter section. A removable cover or the like may be provided to expose the adhesive before installing the filter assembly on the first housing section. In one embodiment, 20 this adhesive is disposed beyond the first recess that may be formed in the first housing section and that may receive the breather filter section as noted above.

The breather filter section and the recirculation filter section of the filter assembly may be disposed in different orientations when installed in the data storage device in the case of the

second aspect. In one embodiment, the recirculation filter section is disposed at least generally perpendicular to the breather filter section when the filter assembly is installed in the data storage device. The breather filter section may be oriented so as to be at least generally parallel with the computer-readable storage medium. In one embodiment, the breather filter section is disposed 5 under the computer-readable storage medium in at least somewhat of a horizontal orientation, while the recirculation filter section is disposed beyond the perimeter of the computer-readable storage medium, for instance in at least somewhat of a vertical orientation. Both the breather filter section and the recirculation filter section may be attached or anchored to the data storage device in any appropriate manner (e.g., via adhesive). It may be beneficial for the breather filter 10 section to be at least generally flush with perimeter portions of the first housing section that are disposed about the above-noted first recess in which the breather filter section may be positioned, for instance so as to reduce its impact on the fluid flow within the data storage device during operation.

The filter assembly utilized by the second aspect includes an appropriate packaging for 15 the breather filter section and the recirculation filter section. This packaging may include a hinge of any appropriate type between the breather filter section and the recirculation filter section. This would allow the filter assembly to be shipped in a "flat" orientation, but yet still allow the recirculation filter section to be moved relative to the breather filter section (e.g., pivoted at least generally about the breather filter section) when installing the filter assembly on the first housing 20 section. In one embodiment, the filter assembly may be characterized as a laminated structure, formed entirely of multiple layers or sheets of one or more appropriate materials. Another way to characterize this packaging that may be utilized by the filter assembly is that it is of a flexible or compliant nature. The above-noted hinge could then be in the form of a necked-down region

in the packaging, or otherwise formed directly in that portion of the packaging, that interconnects the breather filter section and the recirculation filter section.

Both the breather filter section and the recirculation filter section may be of any appropriate configuration for the filter assembly used by the second aspect. In one embodiment, 5 the breather filter section is at least generally wedge-shaped in plan view. That is, a pair of opposing side edges of the breather filter section taper inwardly progressing from one end of the breather filter section toward the opposite end of the breather filter section. What may then be characterized as the wide end of the breather filter section may be located at an interconnection between the breather filter section and the recirculation filter section. In the case where the 10 breather filter section is disposed under or beneath the computer-readable storage medium and where this computer-readable storage medium is in the form of a rotatable disk, this could then dispose the narrow end of the breather filter section closer to a rotational of the disk than the wide end of the breather filter section. Preferably, the breather filter section is disposed at or near the outer diameter of this disk in a low pressure region. The wide end of the breather filter 15 section, the narrow end of the breather filter section, or both may have an arcuate contour or shape in plan view. For instance, the wide end of the breather filter section may extend between the opposing side edges of the breather filter section at least generally parallel with a perimeter of the above-noted rotatable disk. The narrow end of the breather filter section may be disposed at least generally parallel with the wide end as well.

20 The breather filter section of the filter assembly utilized by the second aspect may include any appropriate filtering media. Typically the filtering media for the breather filter section will provide both a chemical filtration and an adsorption function. An adsorbent may be used as the filtering media for the breather filter section, for instance to provide both chemical and humidity

control. Representative adsorbents that may be used for the filtering media of the breather filter section for the filter assembly include without limitation activated carbon, carbon tablets, silica gel tablets, carbon held in PTFE, and carbon held on a web. The filtering media for the breather filter section may be in any appropriate form, may utilize any appropriate material(s), may 5 include any appropriate combination of multiple filtering materials, or any combination of the foregoing.

The recirculation filter section of the filter assembly utilized by the second aspect may include any appropriate filtering media, and may provide idle diffusion resistance and recirculation particle filtration functions. Typically the filtering media of the recirculation filter 10 section will provide a mechanical filtering function, an electrostatic filtering function (e.g., so as to attract charged particles or such that there is an electrical interaction between the filtering media of the recirculation filter section and at least certain particulates that may exist within the data storage device), or both. The recirculation filter section could also use activated carbon or the like, for instance to provide chemical and humidity control. In a preferred embodiment, the 15 filtering media for the recirculation filter section is in the form of an electrostatic media. The filtering media for the recirculation filter section may be in any appropriate form, may utilize any appropriate material(s), may include any combination of multiple filtering materials, or any combination of the foregoing.

The breather filter section of the filter assembly used by the second aspect includes an 20 appropriate filtering media, and this packaging may include first and second packaging sections that are disposed on opposite sides of this filtering media in relation to the flow through the filtering media. The filter assembly in this case is installed such that first packaging section associated with the breather filter section is disposed between the first housing section and the

filtering media for the breather filter section. The second packaging section would then be disposed between the filtering media and the second housing section.

In one embodiment of the second aspect, the above-noted first and second packaging sections associated with the breather filter section have a different permeability. Stated another 5 way, the first and second packaging sections provide a different resistance to flow therethrough to reach the filtering media of the breather filter section. For instance, the second packaging section may have a larger or higher permeability than the first packaging section. That is, the packaging may be configured such that there is less resistance to a flow from within the data storage device to the filtering media of the breather filter section through the second packaging 10 section, than to a flow to the filtering media of the breather filter section emanating from outside of the data storage device and directed through the first port and then through the first packaging section. The first packaging section does, however, allow for at least some flow through the first packaging section to the filtering media of the breather filter section.

The recirculation filter section used by the filter assembly in accordance with the second 15 aspect may include packaging for containing an appropriate filtering media as well. This packaging may be selected for controlling the flow through the recirculation filter section.

In one embodiment, the data storage device of the second aspect is what is commonly referred to in the art as a disk drive. Disk drives of any appropriate configuration may utilize the filter assembly that is used by the second aspect. The filter assembly described in relation to the 20 second aspect may be appropriate for various other applications, and therefore may be presented without any application-specific limitations.

A third aspect of the present invention is directed to a disk drive filter assembly that includes both a breather filter section and a recirculation filter section that are disposed within a

common packaging. Generally, the breather filter section is disposed within a fluid path extending between an interior and an exterior of the disk drive, while the recirculation filter section is disposed within a fluid path that is entirely contained within an interior of the disk drive.

5        The packaging associated with the breather filter section of the third aspect includes first and second packaging sections that are disposed on opposite sides of an adsorbent used by of the breather filter section. "Opposite sides" means in relation to the flow through the adsorbent of the breather filter section. The first and second packaging sections have different permeabilities, with the first packaging section (drive side) being more permeable than the second packaging  
10      section (environment side).

Various refinements exist of the features noted in relation to the third aspect of the present invention. Further features may also be incorporated in the third aspect of the present invention as well. These refinements and additional features may exist individually or in any combination. The common packaging for the breather filter section and the recirculation filter  
15      section may include a hinge of any appropriate type, and this hinge may be located between the breather filter section and the recirculation filter section. This would allow the filter assembly to be shipped in a "flat" orientation, but yet still allow the recirculation filter section to be moved relative to the breather filter section (e.g., pivoted at least generally about the breather filter section) when installing the filter assembly in a disk drive. In one embodiment, the filter  
20      assembly may be characterized as a laminated structure, formed entirely of multiple layers or sheets of one or more appropriate materials. Another way to characterize this packaging that may be utilized by the filter assembly is that it is of a flexible or compliant nature. The above-noted hinge could then be in the form of a necked-down region in the packaging, or otherwise

formed directly in that portion of the packaging, that interconnects the breather filter section and the recirculation filter section.

Both the breather filter section and the recirculation filter section may be of any appropriate configuration in the case of the third aspect. In one embodiment, the breather filter 5 section is at least generally wedge-shaped in plan view. That is, a pair of opposing side edges of the breather filter section taper inwardly progressing from one end of the breather filter section toward the opposite end of the breather filter section. What may then be characterized as the wide end of the breather filter section may be located at an interconnection between the breather filter section and the recirculation filter section. In the case where the breather filter section is 10 disposed under or beneath a computer-readable storage medium of a disk drive, and where this computer-readable storage medium is in the form of a rotatable disk, this could then dispose the narrow end of the breather filter section closer to a rotational of the disk than the wide end of the breather filter section. Preferably, the breather filter section is disposed at or near the outer diameter of this disk in a low pressure region. The wide end of the breather filter section, the 15 narrow end of the breather filter section, or both may have an arcuate contour or shape in plan view. For instance, the wide end of the breather filter section may extend between the opposing side edges of the breather filter section at least generally parallel with a perimeter of the above-noted rotatable disk. The narrow end of the breather filter section may be disposed at least generally parallel with the wide end as well.

20 The breather filter section of the filter assembly utilized by the third aspect may include any appropriate filtering media. Typically the filtering media for the breather filter section will provide both a chemical filtration and an adsorption function. An adsorbent may be used as the filtering media for the breather filter section, for instance to provide both chemical and humidity

control. Representative adsorbents that may be used for the filtering media of the breather filter section for the filter assembly include without limitation activated carbon, carbon pellets, silica gel tablets, carbon held in PTFE, and carbon held in a web. The filtering media for the breather filter section may be in any appropriate form, may utilize any appropriate material(s), may 5 include any appropriate combination of multiple filtering materials, or any combination of the foregoing.

The recirculation filter section of the filter assembly utilized by the third aspect may include any appropriate filtering media, and may provide idle diffusion resistance and recirculation particle filtration functions. Typically the filtering media of the recirculation filter 10 section will provide a mechanical filtering function, an electrostatic filtering function (e.g., so as to attract charged particles or such that there is an electrical interaction between the filtering media of the recirculation filter section and at least certain particulates that may exist within the data storage device), or both. The recirculation filter section could also use activated carbon or the like, for instance to provide chemical and humidity control. In a preferred embodiment, the 15 filtering media for the recirculation filter section is in the form of an electrostatic media. The filtering media for the recirculation filter section may be in any appropriate form, may utilize any appropriate material(s), may include any combination of multiple filtering materials, or any combination of the foregoing.

The packaging for the filter assembly of the third aspect may include an adhesive that is 20 disposed about the breather filter section. That is, "about" means that no portion of this adhesive is disposed over the breather filter section in this case. A benefit of this type of configuration is that the adhesive itself does not reduce the area through which a flow may proceed through the above-noted first packaging section to reach the filtering media of the breather filter section.

Any adhesive that is appropriate for use in a disk drive environment may be utilized. The adhesive may be in the form of a layer formed on the packaging that houses the breather filter section and the recirculation filter section. A removable cover or the like may be provided to expose the adhesive before installing the filter assembly in the disk drive. A similar bonding system may also be provided in relation to the recirculation filter section.

BRIEF DESCRIPTION OF THE SEVERAL  
VIEWS OF THE DRAWING

Figure 1 is a top or plan view of one embodiment of a disk drive.

10 Figure 2 is an exploded, perspective view of one embodiment of a disk drive housing that may be utilized by the disk drive of Figure 1.

Figure 3 is a side view of one embodiment of a flying-type slider that may be used by the disk drive of Figure 1.

Figure 4 is a simplified electrical component block diagram of the disk drive of Figure 1.

15 Figure 5 is a cross-sectional view of one embodiment of a multi-functional filter assembly that may be used by a disk drive, including the disk drive of Figure 1.

Figure 6 is a side view of another embodiment of a multi-functional filter assembly that may be used by a disk drive, including the disk drive of Figure 1.

Figure 7 is a top view of the multi-functional filter assembly of Figure 6.

20 Figure 8 is a cutaway, side view of the multi-functional filter assembly of Figure 6 installed in one embodiment of a base plate for a disk drive.

Figure 9 is a cutaway, side view of the multi-functional filter assembly of Figure 6 installed in another embodiment of a base plate for a disk drive.

Figure 10 is a top view of another embodiment of a multi-functional filter assembly that

may be used by a disk drive, including the disk drive of Figure 1.

Figure 11 is a top view of the multi-functional filter assembly of Figure 10 installed in one embodiment of a base plate for a disk drive.

5

## DETAILED DESCRIPTION OF THE INVENTION

The present invention will now be described in relation to the accompanying drawings that at least assist in illustrating its various pertinent features. One embodiment of a disk drive 10 is illustrated in Figures 1-4. The disk drive 10 generally includes a disk drive housing 16 of any appropriate configuration that defines an enclosed space for the various disk drive components. Here the housing 16 includes a base plate 14 that is typically detachably interconnected with a cover 12. A suitable gasket 13 may be disposed between the cover 12 and the base plate 14 to enhance the seal therebetween.

The disk drive 10 includes one or more data storage disks 18 of any appropriate computer-readable data storage media. Typically both of the major surfaces of each data storage disk 18 include a plurality of concentrically disposed tracks for data storage purposes. Each disk 18 is mounted on a hub or spindle 22, which in turn is rotatably interconnected with the disk drive base plate 14 and/or cover 12. Multiple data storage disks 18 would be mounted in vertically spaced and parallel relation on the spindle 22 and may be characterized as a hard disk assembly or HDA 17. Rotation of the disk(s) 18 is provided by a spindle motor 24 that is appropriately coupled to the spindle 22 to simultaneously spin the data storage disk(s) 18 at an appropriate rate.

The disk drive 10 also includes head stack assembly or HSA 26, that in turn includes one or more individual rigid actuator arms 30. All actuator arms 30 extend out from an actuator body

28. This actuator body 28 is mounted on a pivot bearing 34. Each actuator arm 30 pivots about the pivot bearing 34, which in turn is rotatably supported by the base plate 14 and/or cover 12. Multiple actuator arms 30 would be disposed in vertically spaced relation, with one actuator arm 30 typically being provided for each major data storage surface of each data storage disk 18 of 5 the disk drive 10. Other actuator arm configurations could be utilized as well, such as an "E" block having one or more rigid actuator arm tips or the like that cantilever from a common structure. Unless otherwise noted herein, the term "actuator arm" encompasses both an actuator arm and an actuator arm tip.

Movement of each actuator arm 30 is provided by an appropriate head stack assembly 10 drive, such as a voice coil motor 62 or the like. The voice coil motor 62 may be characterized as a rotary drive. The voice coil motor 62 is a magnetic assembly that controls the movement of each of the actuator arms 30 under the direction of control electronics 66. Typical components of the voice coil motor 62 are a coil 63 that may be mounted one of the actuator arms 30 or structure pivotable therewith (e.g., on structure interconnected with the actuator body 28), and a 15 separate magnet 64 that is disposed above and below this coil 63 (the upper magnet not being shown in Figure 1). The magnets 64 will typically be mounted on the housing 16. Any appropriate head stack assembly drive type may be utilized by the disk drive 10, including a linear drive (for the case where each of the actuator arms 30 is interconnected with the base plate 14 and/or cover 12 for linear movement versus the illustrated pivoting movement about the pivot 20 bearing 34), as well as other types of rotational/pivoting drives.

A head-gimbal assembly or HGA 36 is interconnected with each actuator arm 30 and includes a load beam or suspension 38 that is attached to the free end of each actuator arm 30 or actuator arm tip, and cantilevers therefrom. All HGAs 36 are part of the HSA 28. Typically the

suspension 38 of each HGA 36 is biased at least generally toward its corresponding disk 18 by a spring-like force. A slider 42 is disposed at or near the free end of each suspension 38. What is commonly referred to in the art as the "head" 44 (e.g., at least one transducer) is appropriately mounted on the slider 42 and is used in disk drive read/write operations. Various types of 5 read/write technologies may be utilized by the head 44 on the slider 42. In any case, the biasing forces exerted by the suspension 38 on its corresponding slider 42 thereby attempt to move the slider 42 in the direction of its corresponding disk 18. Typically this biasing force is such that if the slider 42 were positioned over its corresponding disk 18, without the disk 18 being rotated at a sufficient velocity, the slider 42 would be in contact with the disk 18.

10        Each head 44 is interconnected with the control electronics 66 of the disk drive 10 by a flex cable 70 that is typically mounted on the actuator arm assembly 26. Signals are exchanged between the head 44 on the slider 42 and its corresponding data storage disk 18 for disk drive read and/or write operations. In this regard, the voice coil motor 62 pivots the actuator arm(s) 30 to simultaneously move each head 44 on its slider 42 along a path 80 and "across" the 15 corresponding data storage disk 18 to position the head 44 at the desired/required radial position on the disk 18 (i.e., at the correct track on the data storage disk 18) for disk drive read/write operations.

When the disk drive 10 is not in operation, the actuator arm(s) 30 is pivoted to a "parked position" to dispose each slider 42 in a desired position relative to its corresponding data storage 20 disk 18. The "parked position" may be at least generally at or more typically beyond a perimeter of its corresponding data storage disk 18 or at a more interior location of the corresponding disk 18, but in any case typically in vertically spaced relation to its corresponding disk 18. This is commonly referred to in the art as being a dynamic load/unload disk drive configuration. In this

regard, the disk drive 10 includes a ramp assembly 78 that is disposed beyond a perimeter of the data storage disk 18 in the illustrated configuration to typically both move the corresponding slider 42 vertically away from its corresponding data storage disk 18 and to also exert somewhat of a retaining force on the corresponding actuator arm 30. Any configuration for the ramp 5 assembly 78 that provides the desired "parking" function may be utilized. The disk drive 10 could also be configured to be of the contact start/stop type, where each actuator arm 30 would pivot in a direction to dispose the slider(s) 42 typically toward an inner, non-data storage region of the corresponding data storage disk 18. Terminating the rotation of the data storage disk(s) 18 in this type of disk drive configuration would then result in the slider(s) 42 actually establishing 10 contact with or "landing" on their corresponding data storage disk 18, and the slider 42 would remain on the disk 18 until disk drive operations are re-initiated. In either configuration, it may be desirable to at least attempt to retain the actuator arm(s) 30 in this parked position if the disk 15 drive 10 is exposed to a shock event. In this regard, the disk drive 10 includes an actuator arm assembly latch 74 that moves from a non-latching position to a latching position to engage an actuator arm 30 so as to preclude the same from pivoting in a direction which would tend to drag 15 the slider(s) 42 across its corresponding data storage disk 18.

The slider 42 of the disk drive 10 may be configured to "fly" on an air bearing during rotation of its corresponding data storage 18 at a sufficient velocity. This is schematically illustrated in Figure 3 where a lower surface 54 of the slider 42 would include an appropriate air-bearing-surface (ABS) system (not shown). Here the direction of the rotation of the disk 18 relative to the slider 42 is represented by the arrow, while the fly height of the slider 42 is represented by reference numeral 58 (measured from a reference plane of the mean of the surface roughness of the disk 18). In Figure 3, the slider 42 is disposed at a pitch angle such that its 20

leading edge 46 of the slider 42 is disposed further from its corresponding data storage disk 18 than its trailing edge 50. The transducer(s) 44 would typically be incorporated on the slider 42 at least generally toward its trailing edge 50 since this is positioned closest to its corresponding disk 18. Other pitch angles could be utilized for flying the slider 42. The disk drive 10 could also be 5 configured for contact or near-contact recording (not shown).

Figure 4 illustrates a simplified electrical component block diagram of the disk drive 10 of Figure 1. The control electronics 66 in this case includes a controller 90 and a servo control unit 86. The disk drive 10 in Figure 4 also includes a channel 82, as well as an interface 94 for interconnecting the disk drive 10 with a host computer 98. During operation of the disk drive 10, 10 the data storage disk 18 rotates. Data is stored on the data storage disk 18 in substantially concentric tracks. Data may be read from or written to the data storage disk 18 by moving the slider 42 and its head 44 to the desired track and performing the desired communication operation (i.e., a read or write operation). In one embodiment, the data storage disk 18 includes a magnetic media having concentric read/write tracks and the head 44 includes at least one 15 transducer that is capable of communicating with this magnetic data storage disk 18.

The voice coil motor 62 receives servo control information from the servo control unit 86 to cause the voice coil motor 62 to move each actuator arm 30 and its corresponding head 44 when repositioning of the head(s) 44 is desired/required. In this regard, the head(s) 44 may periodically read positioning information from the surface of the corresponding data storage disk 20 18 and transmit the positioning information to the servo control unit 86 via the channel 82. The servo control unit 86 compares the present position of the head(s) 44 to a desired position, with movement of the actuator arm(s) 30 being made as required for proper track alignment.

The channel 82 receives a number of inputs for processing so that data may be

manipulated by the devices internal and external, such as the host computer 98, which is again interconnected with the disk drive 10 via the interface 94. One operation of the channel 82 is to receive an analog signal from the head(s) 44 and to convert the analog signal to a digital signal recognized by the host computer 98. In addition, the channel 82 facilitates the storage of 5 information from the host computer 98 to the data storage disk(s) 18 by encoding data signals from the host computer 98 and creating a write signal, from the encoding data, which is transmitted to the head(s) 44 for storage on the corresponding data storage disk 18.

The controller 90 controls the timing and operation of other elements of the disk drive 10. The controller 90 receives input/output requests from the host computer 98 via the interface 94. 10 Based on the input to the controller 90, the controller 90 delivers appropriate commands to the servo control unit 86 and the channel 82. For example, in a read operation, the controller 90 commands the servo control unit 86 to move the head(s) 44 to the desired track on the corresponding data storage disk 18 such that the data written on the disk 18 may be transferred to the host computer 98. Accordingly, the servo control unit 86 moves the head(s) 44 to the desired 15 track on the corresponding data storage disk 18 using the servo positioning information read from the data storage disk 18 by the corresponding head 44. In turn, the head(s) 44 reads the information from the corresponding data storage disk 18 and transmits information to the channel 82 that converts the information so that it may be interpreted by the host computer 98.

One embodiment of a multi-functional filter assembly that may be used by the disk drive 20 10 of Figure 1, as well as other disk drive configurations, is illustrated in Figure 5 and is identified by reference numeral 100. There are two main parts to the filter assembly 100, namely a breather filter section 104 and a recirculation filter section 112. Both the breather filter section 104 and the recirculation filter section 112 are housed within a common packaging 120.

Generally, the breather filter section 104 provides a filtering function for any fluid communication between the interior and the exterior of a disk drive that utilizes the filter assembly 100. The recirculation filter section 112, on the other hand, provides a filtering function within the interior of a disk drive that utilizes the filter assembly 100. That is, the 5 recirculation filter section 112 filters an internal flow within a disk drive that utilizes the filter assembly 100.

The breather filter section 104 of the filter assembly 100 includes any appropriate filtering media 108 for a breather filter application for a disk drive. The breather filter section 104 may provide chemical filtration and adsorption functions. Typically the filtering media 108 will include an adsorbent for the breather filter section 104 to provide chemical and humidity control. Representative adsorbents that may be used for the filtering media 108 of the breather filter section 104 for the filter assembly 100 include without limitation activated carbon, carbon tablets, silica gel tablets, carbon held in PTFE, and carbon held on a web. The filtering media 108 may be in any appropriate form in the breather filter section 104, may utilize any appropriate 10 material(s), may include any appropriate combination of multiple filtering materials, or any combination of the foregoing.

15

The recirculation filter section 112 of the filter assembly 100 includes any appropriate filtering media 116 for a recirculation filter application for a disk drive. This may include providing idle diffusion resistance and recirculation particle filtration. Typically the filtering 20 media 116 will provide a mechanical filtering function, an electrostatic filtering function (e.g., so as to attract charged particles or such that there is an electrical interaction between the filtering media 116 and at least certain particulates within a disk drive that utilizes the filter assembly 100), or both. In a preferred embodiment, the filtering media 116 is in the form of an

electrostatic media that is appropriate for disk drive recirculation filter applications. The recirculation filter section 112 may include activated carbon or the like, for instance to provide chemical and humidity control. The filtering media 116 may be in any appropriate form in the recirculation filter section 112, may utilize any appropriate material(s), may include any 5 combination of multiple filtering materials, or any combination of the foregoing.

Both the breather filter section 104 and the recirculation filter section 112 are housed within the common packaging 120 as noted. One function of the packaging 120 is to contain the filtering media 108 of the breather filter section 104, as well as the filtering media 116 of the recirculation filter section 112. Any appropriate material or combination of materials that will 10 suitably retain the filtering media 108 of the breather filter section 104, as well as the filtering media 116 of the recirculation filter section 112, may be a candidate for the packaging 120. However, at least one other desired function provided by the packaging 120 may have an impact on material selection and/or the configuration of the packaging 120 for the filter assembly 100.

In a preferred embodiment, the packaging 120 is pliable or flexible (e.g., formed by one 15 or more sheets of one or more materials) to facilitate installation of the filter assembly 100 into a disk drive in a manner that will be discussed in more detail below. Generally, the filter assembly 100 of Figure 5 may be characterized as a laminated or layered structure and is sufficiently flexible such that the recirculation filter section 112 may be moved (e.g., pivoted) into an orientation such that the recirculation filter section 112 is at least generally perpendicular to the 20 breather filter section 104. This would also allow for shipment of the filter assembly 100 in a "flat" condition, and thereafter allow the same to be "bent" into the desired configuration for installation into a disk drive. Another characterization of the packaging 120 is that it provides a "label" or "label-like" configuration for the filter assembly 100. Certain aspects of the filter

assembly 100 are not contingent upon this "flexible" nature of the packaging 120.

Components of the packaging 120 for the case of the illustrated embodiment include an upper layer or sheet 124, a lower layer or sheet 128, and at least one intermediate layer or sheet 132 that is disposed between the upper layer 124 and the lower layer 128. The upper layer 124, 5 intermediate layer(s) 132, and lower layer 128 may be joined together at locations 136 to define a perimeter for both the breather filter section 104 and the recirculation filter section 112. Any way of joining these layers 124, 132, and 128 may be utilized, including without limitation adhesives, welding, heat sealing or thermal bonding, and ultrasonic bonding. Moreover, the upper layer 124, intermediate layer(s) 132, and lower layer 128 may be joined together to define 10 a hinge 138 in the structure of the packaging 120 to facilitate the pivotatation/rotation of the recirculation filter section 112 relative to breather filter section 104 when installing the filter assembly 100 in a disk drive. Any way of configuring the packaging 120 to allow the recirculation filter section 112 to be moved relative to the breather filter section 104 during installation may be utilized. That is, the hinge 138 may be of any appropriate configuration.

15 Another function provided by the packaging 120 is controlling the flow to the filtering media 108 of the breather filter section 104 from both the drive side and from the environment side. It should be appreciated that this functionality of the packaging 120 may be realized with configurations for the packaging 120 other than the above-described "flexible" nature of the packaging 120 in the illustrated and preferred embodiment. There is somewhat of a key 20 relationship between the upper layer 124 and the lower layer 128 of the packaging 120 at least in relation to the breather filter section 104 and control of its related flow. Generally, at least those portions of the upper layer 124 and the lower layer 128 that are disposed over the filtering media 108 of the breather filter section 104 have a different porosity or permeability. The upper layer

124 will face the interior of a disk drive that utilizes the filter assembly 100, while the lower layer 128 will face at least generally away from the interior of the disk drive. Typically, the lower layer 128 will face a base plate of a disk drive that utilizes the filter assembly 100. In any case, a flow emanating from inside the disk drive will first pass through the upper layer 124 of 5 the packaging 120 before reaching the filtering media 108 of the breather filter section 104, while a flow emanating from the environment will first pass through the lower layer 128 of the packaging 120 before reaching the filtering media 108.

At least that portion of the lower layer 128 of the packaging 120 that is disposed over the filtering media 108 of the breather filter section 104 is less porous or has a lower permeability 10 than at least that portion of the upper layer 124 that is disposed over the filtering media 108 of the breather filter section 104. That is, there is less resistance to a flow entering the filtering media 108 of the breather filter section 104 through the upper layer 124 of the packaging 120 (from inside the disk drive) than to a flow entering the filtering media 108 of the breather filter section 104 through the lower layer 128 of the packaging 120 (from outside the drive). It will 15 typically be preferred that the resistance to flow through the upper layer 124 of the packaging 120 to the filtering media 108 of the breather filter section 104 be as low as possible.

There are a number of ways in which the above-noted flow characteristics to the filtering media 108 of the breather filter section 104, provided by the packaging 120, may be quantified. One is that at least that portion of the upper layer 124 that is disposed over the filtering media 20 108 of the breather filter section 104 is at least about ten times more permeable than at least that portion of the lower layer 128 that is disposed over the filtering media 108 of the breather filter section 104. The lower layer 128 does allow at least some flow therethrough. Yet another is that the pressure drop proceeding through the upper layer 124 of the packaging 120 to the filtering

media 108 of the breather filter section 104 from the drive side is low compared to the pressure drop proceeding through the lower layer 128 of the packaging 120 to the filtering media 108 of the breather filter section 104 from the environment side. Ideally, there would be little to no pressure drop proceeding through the upper layer 124 of the packaging 120 to the filtering media 5 108 of the breather filter section 104 from the drive side.

The illustrated embodiment discloses a single layer to control the flow to the filtering media 108 of the breather filter section 104 from each side (i.e., from the drive side, and from the environment side). This is by no means a requirement of the filter assembly 100. Instead, the packaging 120 over both sides of the filtering media 108 of the breather filter section 104 may be 10 of any configuration that provides the above-noted characteristics with regard to the control of the flow to the filtering media 108. That is, it is accurate to describe the porosity or permeability of the packaging 120 in general over the drive side of the filtering media 108 of the breather filter section 104 and over the environment side of the filtering media 108 of the breather filter section 104 in the above-noted terms that were addressed in relation to the upper layer 124 and 15 the lower layer 128 alone. For instance, the packaging 120 could be in the form of one or more layers disposed on the drive side of the filtering media 108 of the breather filter section 104, and one or more layers on the environment side of the filtering media 108 of the breather filter section 104 so as to have the drive side of the packaging 120 over the filtering media 108 be more porous or permeable than the packaging 120 over the filtering media 108 on the 20 environment side of the filtering media 108.

Continuing with the foregoing, the packaging 120 for the filter assembly 100 may be characterized as including: 1) a high permeability section 122a through which a flow be directed to the filtering media 108 of the breather filter section 114 from inside the disk drive; and 2) a

low permeability section 122b through which a flow may be directed to the filtering media 108 of the breather filter section 104 from outside or external to the disk drive. That is, the high permeability section 122a of the packaging 120 will have the above-noted characteristics of the upper layer 124 of the packaging 120, while the low permeability section 122b of the packaging 5 120 will have the above-noted characteristics of the lower layer 128 of the packaging 120. Both the high permeability section 122a and the low permeability section 122b may be formed from one or more layers of one or more materials, or in any other appropriate manner, to realize the above-noted flow control characteristics.

Another characteristic of note in relation to the breather filter section 104 of the filter 10 assembly 100 relates to the area through which a flow may be directed to reach the filtering media 108 of the breather filter section 104. Generally, the surface area of that region through which a flow may be directed through the lower layer 128 of the packaging 120 (or stated another way the low permeability section 122b of the packaging 120) to the filtering media 108 of the breather filter section 104 is relatively large. Preferably, a flow emanating from outside 15 the disk drive may proceed through the packaging 120 throughout the entire region of the packaging 120 that is disposed over the filtering media 108 of the breather filter section 104. Stated another way, a flow emanating from outside the disk drive preferably may proceed through any portion of the packaging 120 that overlies the filtering media 108 of the breather filter section 104.

20 The filtering media 116 for the recirculation filter section 112 of the filter assembly 100 is contained between the upper layer 124 and the intermediate layer 132 of the packaging 120. An aperture 130 exists in that portion of the low permeability lower layer 128 of the packaging 120 that is disposed over the filtering media 116 of the recirculation filter section 112. The

upper layer 124 and the intermediate layer 132 of the packaging 120 contain the filtering media 116 for the recirculation filter section 112. The upper layer 124 and the intermediate layer 132 of the packaging 120 also at least in part control the flow through the filtering media 116 of the recirculation filter section 112. Generally, the portion of the upper layer 124 and intermediate 5 layer 132 of the packaging 120 that are disposed over the filtering media 116 of the recirculation filter section 112 are porous or of a high permeability to facilitate flow through the recirculation filter section 112 (e.g., to provide a low flow resistance). Stated another way, there is preferably a low pressure drop proceeding through both the upper layer 124 and the intermediate layer 132 of the packaging 120 to reach/exit the filtering media 116 of the recirculation filter section 112.

10 Since the upper layer 124 is disposed over both the filtering media 108 of the breather filter section 104 and the filtering media 116 of the recirculation filter section 112, the characteristics of the upper layer 124 discussed above in relation to the breather filter section 104 are equally applicable to the upper layer 124 in relation to the recirculation filter section 112. Although the same upper layer 124 is disposed over both the filtering media 108 in the breather filter section 15 104, and over the filtering media 116 in the recirculation filter section 112 (e.g., for ease of manufacturing), such need not be the case. Typically the porosity or permeability of the intermediate layer 132 of the packaging 120 will be at least generally the same as that of the upper layer 124 of the packaging 120. However, the packaging 120 on each side of the recirculation filter section 112 (e.g., on the inlet corresponding with the upper layer 124, and on 20 the exit side corresponding with the intermediate layer 132 in the case of the recirculation filter section 112) may be of any appropriate porosity or permeability.

The illustrated embodiment discloses a single layer to control the flow through the filtering media 116 of the recirculation filter section 112 from each side. This is by no means a

requirement of the filter assembly 100. Instead, the packaging 120 over both sides of the filtering media 116 of the recirculation filter section 112 may be of any configuration that provides a desired flow through the filtering media 116 of the recirculation filter section 112. That is, it is accurate to describe the porosity or permeability of the packaging 120 in general 5 over both sides of the filtering media 116 of the recirculation filter section 112 in the above-noted terms that were addressed in relation to the upper layer 124 and the intermediate layer 132. For instance, the packaging 120 could be in the form of one or more layers disposed on the "inlet" side of the filtering media 116 of the recirculation filter section 112, and one or more layers on the "outlet" side of the filtering media 116 of the recirculation filter section 112 so as to provide 10 desired flow characteristics through the recirculation filter section 112 of the filter assembly 100.

For instance, the packaging 120 for the filter assembly 100 may be characterized as including: 15 1) a high permeability section 122c through which a flow be directed to the filtering media 116 of the recirculation filter section 112; and 2) a high permeability section 122d through which a flow may be directed out of the recirculation filter section 112 and back into the interior of the disk drive. That is, the high permeability section 122c and high permeability section 122d of the packaging 120 may have the above-noted characteristics of the upper layer 124 of the packaging 120.

Other layers could be included in the packaging 120 and for any appropriate purpose. For instance, the packaging 120 about the perimeter of each of the breather filter section 104 and 20 the recirculation filter section 112 could included an appropriate "stiffening" layer.

An adhesive layer 117 may be provided on the packaging 120 for the filter assembly 100 and as illustrated by the dashed lines in Figure 5. This adhesive layer 117 is disposed about at least part of the breather filter section 104. That is, the adhesive layer 117 may be disposed on

the packaging 120 about the entire perimeter of the breather filter section 104, or the adhesive layer 117 may be disposed on the packaging 120 intermittently about the perimeter of the breather filter section 104. An annular seal is preferred to increase the potential that all flow from outside the disk drive is directed through the filtering media 108 for the breather filter 5 section 104. In any case, an appropriate removable adhesive cover or film 118 may be disposed over the adhesive layer 117, and may be removed to expose the adhesive layer 117 for installation of the filter assembly 100 in a disk drive. In any case, no portion of the adhesive layer 117 overlies the breather filter section 104. Stated another way, the adhesive layer 117 is disposed beyond the perimeter of the breather filter section 104. Therefore, the adhesive layer 10 117 does not limit a flow through the low permeability section 122b of the packaging 120 to the filtering media 108 of the breather filter section 104 for the filter assembly 100. The adhesive layer 117 is also on the side of the packaging 120 having the low permeability section 122b. As will be discussed in more detail below, this "side" of the filter assembly 100 may be disposed within a recess formed in a base plate of a disk drive that utilizes the filter assembly 100. The 15 adhesive layer 117 may also be disposed about at least part of the recirculation filter section 112 as well and as illustrated in Figure 5. The adhesive could also be separately applied to the packaging 120 and/or corresponding portions of the disk drive prior to installing the filter assembly 100 in the disk drive.

Another embodiment of a filter assembly is schematically illustrated in Figure 6-7, and is 20 identified by reference numeral 140. The filter assembly 140 may be configured in the same manner as the filter assembly 100 discussed above in relation to Figure 5 (e.g., the cross-sectional configuration of the filter assembly 140 may be the same as that of the filter assembly 100, including using the same layered construction). Generally, the filter assembly 140 includes

a breather filter section 144 having a filtering media 146, as well as a recirculation filter section 148 having a filtering media 150. Both the breather filter section 144 and the recirculation filter section 148 are contained or housed within a common packaging 152. A hinge 156 is formed in the packaging 152 to facilitate movement of the recirculation filter section 148 relative to the 5 breather filter section 144 when installing the filter assembly 140 in a disk drive. The hinge 156 may be of any appropriate configuration that allows for the described relative movement.

Like the filter assembly 100 of Figure 5, the packaging 152 for the filter assembly 140 includes a high permeability section 147a on the "drive side" of the filtering media 146 for the breather filter section 144, and a low permeability section 147b on the "environment side" of the 10 filtering media 146 for the breather filter section 144. That is, there is less resistance to a flow proceeding through the high permeability section 147a of the packaging 152 to the filtering media 146 of the breather filter section 144 (i.e., a flow emanating from inside the disk drive) than to a flow proceeding through the low permeability section 147b of the packaging 152 to the filtering media 146 of the breather filter section 144 (i.e., a flow emanating from the 15 environment, or external to the disk drive). The various characteristics presented above in relation to the filter assembly 100 are thereby equally applicable to the filter assembly 140, including without limitation the various ways discussed above for quantifying these flow characteristics.

The breather filter section 144 of the filter assembly 140 is at least generally wedge-shaped in plan view and as illustrated in Figure 7. That is, the opposing side edges 145b, 145c taper at least generally toward each other progressing from the end of the breather filter section 144 proximate the hinge 156, in a direction of the opposite end 145a associated with the breather filter section 144.

Like the filter assembly 100 of Figure 5, the packaging 152 for the filter assembly 140 of Figures 6-7 includes a high permeability section 154a on the "inlet side" to the filtering media 150 for the recirculation filter section 148, and a high permeability section 154b on the "outlet side" from the filtering media 150 for the recirculation filter section 148. The various 5 characteristics presented above in relation to the filter assembly 100 are thereby equally applicable to the filter assembly 140, including without limitation the various ways discussed above for quantifying the flow characteristics through the recirculation filter section 112.

Figure 8 depicts the filter assembly 140 as installed on one embodiment of a base plate 164 that may be used by a disk drive, including without limitation the disk drive 10 of Figure 1. 10 The base plate 164 includes a recess 168 for receiving the breather filter section 144 of the filter assembly 140. This recess 168 is defined by a base 172 and a perimeter-defining side wall 176. A breather port 192 extends from an exterior surface 202 of the base plate 164 and intersects with the recess 168. In the illustrated embodiment, the breather port 192 is an axially extending aperture that intersects with the base 172 of the recess 168. Moreover, the breather port 192 is 15 disposed directly under a perimeter portion of the breather filter section 144 of the filter assembly 140. The breather port 192 may be disposed at any appropriate location of the base plate 164 so as to extend between any part of the exterior surface 202 of the base plate 164 and the recess 168.

There are a number of notables in relation to the positioning of the breather filter section 20 144 of the filter assembly 140 within the recess 168 of the base plate 164. One is that the low permeability section 147b of the packaging 152 faces the base plate 164, and further is disposed in spaced relation to the base 172 that defines part of the recess 168. That is, a space separates the entirety of the base 172 associated with the base plate 164 from the breather filter section 144

of the filter assembly 140. Therefore, a flow progressing through the breather port 192 from outside the disk drive and into the recess 168 may flow through any portion of the low permeability section 147b of the packaging 152 that overlies the filtering media 146 of the breather filter section 144.

5 The perimeter of the breather filter section 144 for the filter assembly 140 is also disposed in spaced relation to the perimeter-defining side wall 176 of the recess 168 in the base plate 164. That is, a space separates the entirety of the perimeter-defining side wall 176 of the base plate 164 from the perimeter of the breather filter section 144. Fluid within the recess 168 may then also flow into the breather filter section 144 through the perimeter of the breather filter 10 section 144 as well. The packaging 152 over this perimeter portion or annular side of the breather filter section 144 will typically be of the same permeability as the low permeability section 147b of the packaging 152.

An appropriate seal 180 between the base plate 164 and the packaging 152 of the filter assembly 140 may be disposed about the recess 168 so as to force at least a substantial portion 15 of, and more preferably the entirety of, a flow from outside the drive through the filtering media 146 of the breather filter section 144 for the filter assembly 140. The filter assembly 140 may be fixed to the base plate 164 about the recess 168 as well. In one embodiment, an appropriate adhesive is used to attach the filter assembly 100 to the base plate 164, and this adhesive is disposed entirely beyond the recess 168. Stated another way, no adhesive limits or interferes 20 with the flow into the breather filter section 144 of the filter assembly 140 in the same manner discussed above in relation to the Figure 5 embodiment.

The base plate 164 also includes a shroud wall 184 for interfacing with the recirculation filter section 148 of the filter assembly 140. The shroud wall 184 supports the recirculation filter

section 148 in an orientation that is at least generally perpendicular to the breather filter section 144 of the filter assembly 140. An aperture 188 extends through the shroud wall 184 and is aligned with the filtering media 150 of the recirculation filter section 148 for the filter assembly 140. As such, a flow from within the disk drive is able to proceed through the filtering media 5 150 for the recirculation filter section 148, and then through the aperture 188 in the shroud wall 184, at least generally in the direction of the arrows B in Figure 8. An adhesive may be used to anchor or attach the recirculation filter section 148 to the shroud wall 184. Any appropriate way of maintaining the recirculation filter section 148 of the filter assembly 100 in a proper orientation may be utilized.

10 Figure 9 presents a variation of the base plate 164 depicted in Figure 8 for use in combination with the filter assembly 140. Common components/assemblies between the embodiments of Figures 8 and 9 are identified by the same reference numeral. A "single prime" designation is used for those corresponding components/assemblies which differ in at least some respect between the Figure 8 and 9 embodiments. There are two primary differences between 15 the base plate 164' of Figure 9 and the base plate 164 of Figure 8. One is that the base plate 164' of Figure 9 includes what may be characterized as a "meandering" or "tortuous" breather port 192'. This breather port 192' extends from the exterior surface 202 of the base plate 164' to the recess 168. In this case the breather port 192' is something other than axially extending. The breather port 192' may proceed along any path between the exterior surface 202 of the base plate 20 164' and the recess 168. Moreover, the breather port 192' intersects with the perimeter-defining side wall 176 associated with the recess 168 in the case of the Figure 9 embodiment, versus with the base 172 associated with the recess 168 in the case of the Figure 8 embodiment. The breather port 192' may be of any appropriate configuration and formed in any appropriate

manner for providing a diffusion barrier of sorts for any flow from outside the drive that is directed toward the interior of the drive through the breather filter section 144 of the filter assembly 140. It should be appreciated that the inclusion of the low permeability section 147b for the packaging 152 in association with the breather filter section 144 may alleviate the need 5 for such a diffusion barrier, or at least allow for a "simpler" and less costly diffusion barrier. That is, the filter assembly 100 may indeed allow for the type of breather port 192 presented in the Figure 8 embodiment that was discussed above.

The configuration of Figure 9 also differs from configuration of Figure 8 in that the base plate 164' in Figure 9 includes a notch 196 for receiving and supporting the packaging 152 that is 10 disposed about the breather filter section 144 of the filter assembly 140. This disposes the high permeability section 147a of the packaging 152 for the filter assembly 140 at least generally flush with a perimeter surface 200 of the base plate 164' that is disposed adjacent to the recess 168. One advantage of this at least generally coplanar relationship is that the breather filter section 144 of the filter assembly 100 may be disposed under a disk of a disk drive that utilizes 15 the base plate 164', without significantly adversely impacting the flow characteristics within the interior of the disk drive. Figure 9 also illustrates an adhesive 182 between the packaging 152 that is disposed beyond the breather filter section 144 of the filter assembly 140 and the base plate 164'. As in the case of the embodiments of Figures 5 and 6, this adhesive 182 is disposed entirely beyond the recess 168. Stated another way, the adhesive 182 does not limit or interfere 20 with the flow into the breather filter section 144 of the filter assembly 140 through the low permeability section 147b in the same general manner discussed above in relation to the Figure 5 embodiment.

Another embodiment of a filter assembly is schematically illustrated in Figure 10, and is

identified by reference numeral 208. The filter assembly 208 may be configured in the same manner as the filter assembly 100 discussed above in relation to Figure 5 (e.g., the cross-sectional configuration of the filter assembly 208 may be the same as that of the filter assembly 100, including using the same layered construction). Generally, the filter assembly 208 includes

5 a breather filter section 212 having a filtering media 222, as well as a recirculation filter section 226 having a filtering media 230. Both the breather filter section 212 and the recirculation filter section 226 are contained or housed within a common packaging 234. A hinge 246 is formed in the packaging 234 to facilitate movement of the recirculation filter section 226 relative to the breather filter section 212 when installing the filter assembly 208 in a disk drive.

10 Like the filter assembly 100 of Figure 5, the packaging 234 for the filter assembly 208 includes a high permeability section 238a on the "drive side" of the filtering media 222 for the breather filter section 212, and a low permeability section 238b on the "environment side" of the filtering media 222 for the breather filter section 212. That is, there is less resistance to a flow proceeding through the high permeability section 238a of the filtering media 222 of the breather

15 filter section 212 (i.e., a flow emanating from inside the disk drive) than to a flow proceeding through the low permeability section 238b of the packaging 234 to the filtering media 222 of the breather filter section 212 (i.e., a flow emanating from the environment, or external to the disk drive). The various characteristics presented above in relation to the filter assembly 100 are thereby equally applicable to the filter assembly 208, including without limitation the various

20 ways discussed above for quantifying these flow characteristics .

The breather filter section 212 of the filter assembly 208 is at least generally wedge-shaped in plan view and as illustrated in Figure 10. That is, the opposing side edges 218a, 218b taper at least generally toward each other progressing from a wide end 216a of the breather filter

section 212 toward a narrow end 216b of the breather filter section 212. The packaging 234 on the wide end 216a of the breather filter section 212 is also arcuately-shaped. In one embodiment, both the wide end 216a of the breather filter section 212 and the packaging 234 disposed beyond the breather filter section 212 in the direction of the hinge 246 are defined by the same radius as a perimeter of a disk in a disk drive incorporating the filter assembly 208. The illustrated embodiment also has the narrow end 216b of the breather filter section 212, as well as that portion of the packaging 234 that is disposed beyond the breather filter section 212 in a direction that is at least generally away from the hinge 246, being arcuate as well.

The packaging 234 "necks down" between the breather filter section 212 and the recirculation filter section 226 to define the hinge 246 to allow the recirculation filter section 226 to be moved relative to the breather filter section 212 when installing the filter assembly 208 in a disk drive. The hinge 246 may be of any appropriate configuration that allows for the described relative movement. Any appropriate configuration may be incorporated into the packaging 234 to allow the recirculation filter section 226 to be moved relative to the breather filter section 212 during installation.

Like the filter assembly 100 of Figure 5, the packaging 234 for the filter assembly 208 of Figure 10 includes a high permeability section 240a on the "inlet side" to the filtering media 230 of the recirculation filter section 226 of the filter assembly 208, and a high permeability section 240b on the "outlet side" from the filtering media 222 for the recirculation filter section 226 (i.e., opposite the high permeability section 240). The various characteristics presented above in relation to the filter assembly 100 are thereby equally applicable to the filter assembly 208, including without limitation the various way discussed above for quantifying the flow characteristics through the recirculation filter section 112.

Figure 11 illustrates the filter assembly 208 of Figure 10 installed on one embodiment of a base plate 258 of a disk drive 250. The disk drive 250 may be of the same general configuration of the disk drive 10 discussed above in relation to Figure 10 or of any other appropriate configuration. The disk drive 250 includes a disk 282 that rotates in the direction of 5 the arrow A during disk drive operations. This disk 282 is disposed within a recess 262 that is formed in the base plate 258. A perimeter of this recess 262 is defined by a side wall 266. There is a small space between a perimeter 286 of the disk 282 and the side wall 266. The perimeter 286 of the disk 282 and the side wall 266 associated with the recess 262 are at least generally parallel with each other.

10 The breather filter section 212 of the filter assembly 208 is disposed beneath or under the disk 282. The perimeter 286 of the disk 282 and the wide end 216a of the breather filter section 212 are slightly spaced, and are disposed in at least generally parallel relation. Generally, the breather filter section 212 is disposed in a low pressure region within the disk drive. Preferably, the base plate 258 includes a recess of the type discussed above in relation to either of the 15 embodiments of Figures 8 and 9 for receiving the breather filter section 212 (not shown). The base plate 258 includes a breather port 270 that extends completely through the base plate 258 in any appropriate manner. The breather port 270 may be of any appropriate configuration that fluidly interconnects the interior of the disk drive 250 with the environment in which the disk drive 250 is being used, so long as any flow of this type is directed through the breather filter 20 section 212 of the filter assembly 208. Preferably this breather port 270 intersects with a recess formed in the base plate 258, in which the breather filter section 212 is again preferably disposed and in the manner discussed above in relation to either of the embodiments of Figures 8-9.

The base plate 258 is also configured to direct a flow through a channel 272 formed in

the base plate 258, and then through the recirculation filter section 226 of the filter assembly 208. This flow is represented by the arrows in the space between the perimeter 286 of the disk 282 and the side wall 266, as well as by the arrows in the channel 274. The base plate 258 includes a pair of supports 278a, 278b that capture/support opposing edge portions of the recirculation filter section 226 of the filter assembly 208. The supports 278a, 278b are spaced so that the flow therebetween passes through the filtering media 230 of the recirculation filter section 226. The recirculation filter section 226 may be appropriately attached to one or both of these supports 278a, 278b (e.g., using an appropriate adhesive).

Each of the above-described embodiments of multi-functional filter assemblies 100, 140, 10 and 208 may be used in a disk drive of any type and of any appropriate configuration. What is of importance is the control of the flow provided by the packaging used by these filter assemblies 100, 140, and 208, as well as the manner in which a flow is provided through a low permeability section to the breather filter section of these filter assemblies 100, 140, 208 (e.g., the increased area through which a flow may be directed to the filtering media of the breather filter section for 15 these filter assemblies 100, 140, 208; the disposition of the breather filter section for these filter assemblies 100, 140, 208 within a recess formed in a base plate; the spacing provided between the base plate and the low permeability section to the breather filter section of these filter assemblies 100, 140, 208).

The foregoing description of the present invention has been presented for purposes of 20 illustration and description. Furthermore, the description is not intended to limit the invention to the form disclosed herein. Consequently, variations and modifications commensurate with the above teachings, and skill and knowledge of the relevant art, are within the scope of the present invention. The embodiments described hereinabove are further intended to explain best modes

known of practicing the invention and to enable others skilled in the art to utilize the invention in such, or other embodiments and with various modifications required by the particular application(s) or use(s) of the present invention. It is intended that the appended claims be construed to include alternative embodiments to the extent permitted by the prior art.

**Reference Numeral Cross-Reference**

<b>Figures 1-4</b>		62	Voice Coil Motor
10	Disk Drive	25	Coil
12	Cover	64	Magnet
5 13	Gasket	66	Control Electronics
14	Base Plate	70	Flex Cable
16	Disk Drive Housing	74	Actuator Arm Assembly Latch
17	HDD	30	Ramp Assembly
18	Data Storage Disk	82	Channel
10 22	Spindle	86	Servo Control Unit
24	Spindle Motor	90	Controller
26	Head Stack Assembly	94	Interface
28	Actuator Body	35	Host Computer
30	Actuator Arm		
15 34	Pivot Bearing		<b>Figure 5</b>
36	HGA	100	Filter Assembly
38	Suspension	104	Breather Filter Section
42	Slider	40	108 Filtering Media
44	Head	112	Recirculation Filter Section
20 46	Leading Edge	116	Filtering Media
50	Trailing Edge	117	Adhesive Layer
54	Lower Surface	118	Adhesive Cover
58	Fly Height Designation	45	120 Packaging

122a	High Permeability Section	154a	High Permeability Section		
122b	Low Permeability Section	25	154b	High Permeability Section	
122c	High Permeability Section	156	Hinge		
122d	High Permeability Section				
5	124	Upper Layer/Sheet (Porous)	<b>Figures 8-9</b>		
	128	Lower Layer/Sheet (Less Porous)	164	Base Plate	
	130	Aperture (In Lower Layer 128)	30	168	Recess
	132	Intermediate Layer/Sheet (Porous)	172	Base	
	136	Joinder Locations	176	Perimeter-Defining Side Wall	
10	138	Hinge	180	Seal	
			182	Adhesive	
	<b>Figures 6-7</b>		35	184	Shroud Wall
	140	Filter Assembly	188	Aperture	
	144	Breather Filter Section	192	Breather Port	
15	145a	End	196	Notch	
	145b	Side Edge	200	Recess Perimeter Surface	
	145c	Side Edge	40	202	Exterior Surface
	146	Filtering Media			
	147a	High Permeability Section	<b>Figure 10</b>		
20	147b	Low Permeability Section	208	Filter Assembly	
	148	Recirculation Filter Section	212	Breather Filter Section	
	150	Filtering Media	45	216a	Wide End
	152	Packaging	216b	Narrow End	

218a	Side Edge	
218b	Side Edge	25
222	Filtering Media	
226	Recirculation Filter Section	
5	230	Filtering Media
234	Packaging	
238a	High Permeability Section	
238b	Low Permeability	
240a	High Permeability Section	
10	240b	Low Permeability Section
246	Hinge	

**Figure 11**

250	Disk Drive	
15	258	Base Plate
262	Recess	
266	Side Wall	
270	Breather Port	
274	Channel	
20	278	Supports
282	Disk	
286	Disk Perimeter	